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LITERATURE REVIEW ON GEOTEXTILES TO IMPROVE PAVEMENTS FOR GENERAL AVIATION AIRPORTS

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16. Abstract

This report covers a literature search and review to obtain information on geotextile applications related to pavement construction. Applicable information from this study, if sufficient, would then be used to prepare guidelines on design application, material specifications, performance, criteria, and construction procedures for improving subgrade support with geotextiles in general aviation airport pavements.

The study revealed that there are numerous design procedures available for using geotextiles in aggregate surfaced pavements and flexible pavement road construction. However, there is no generally accepted procedure for either type construction. The state-of-the-art has not advanced to the point where design procedures for using geotextiles in paved airport construction are available.

Construction/installation procedures are available for using geotextiles in aggregate surfaced pavements and flexible pavements for roads, and these may be used as an aid in recommending procedures for airport construction.

Results of comprehensive tests by researchers indicate that geogrids have more potential than geotextiles for reinforcement of flexible pavements. Until design procedures for flexible pavements for airports incorporating geotextiles are developed, current standard airport pavement design procedures should continue to be used, and if geotextiles are included in the structure, no structural support should be attributed to geotextiles. Further research on the use of geotextiles to improve subgrade support for general aviation airports should be delayed until the laboratory grid study and field grid tests are completed.

17. Key Words
Geotextile, Pavement, Separation, Reinforcement, Subgrade

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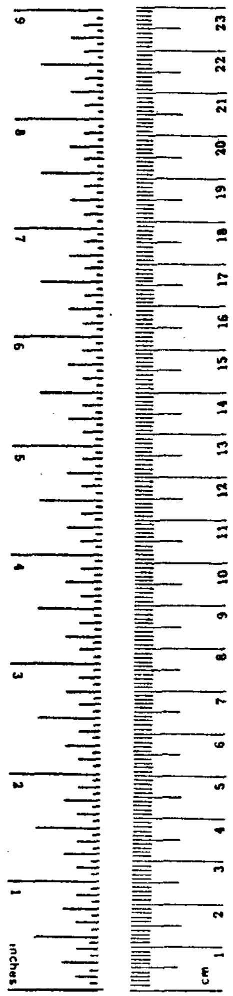
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

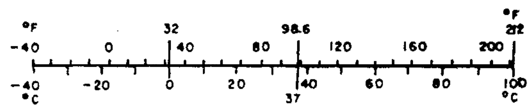
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	* 2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

* 1 in. = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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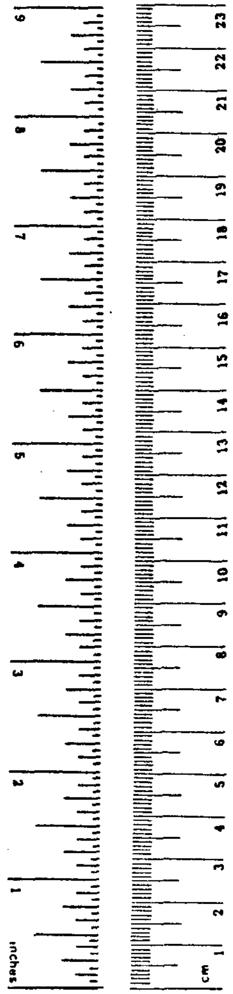

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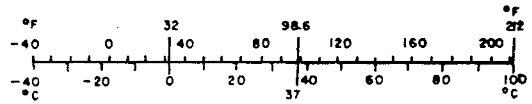

INTRODUCTION

Airport pavement base courses must be composed of good quality material in order to resist shear forces and protect the subgrade from excessive deformation under aircraft wheel loads. The Federal Aviation Administration (FAA) Advisory Circulars which specify acceptable types of aggregate material are provided to airport owners and operators. Such materials are rapidly being depleted, and in many cases, suitable aggregates must be transported considerable distances to reach airport pavement construction sites at high costs.

Research has been accomplished on the use of aggregate filled cells to improve the shearing resistance of base courses. Studies on the effectiveness of grid- and lattice-type reinforcement to reduce vertical deformation of pavement structures over subgrades of various strengths have been pursued in laboratories. However, results have not been verified under field conditions. A laboratory grid study (Phase I, Task 4) and field grid tests (Phase I, Task 5) will be conducted as part of the overall interagency agreement with a separate report to be prepared on that work.

A less expensive alternative may be the use of geotextiles to increase subgrade support. Design guidelines, standardized specifications, and test methods are needed by the FAA field and design engineers to permit them to make decisions regarding the use of geotextiles in general aviation airport pavement construction.

The objective of this study was to conduct a literature search and review to obtain information on geotextile applications related to pavement construction. The information obtained, if sufficient, could then be used to prepare guidelines on design application, material specifications, performance criteria, and construction procedures for improving subgrade support with geotextiles in general aviation airport pavements.

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LITERATURE SEARCH RESULTS

The results of this search revealed considerable references to published information on the use of geotextiles in aggregate surfaced pavement construction. However, only limited references are available to published information on geotextile usage in flexible pavement road construction, and very little is related to usage in airport pavement construction. This published information includes design guidelines, important properties, functions, and construction/installation procedures prepared by researchers, designers, and manufactures/suppliers.

A total of 104 different reports, magazine articles, periodicals, books, and technical papers were reviewed. Responses were received from 9 of 22 written communications for data/information mentioned under the section titled "Literature Review Sources". Five of the responses contained, in addition to product information, design guidelines and construction/installation information for aggregate surfaced pavements and flexible pavements for roads. One source provided information on one of its products used in conjunction with airport pavement construction. However, no design guideline information on geotextile use specifically for airport pavement construction was included with any of the responses. Further information relative to the manufacturer's product in airport pavement will be given in the section entitled, "Flexible Pavements for Airports". A review of the agenda for the 4th International Conference on Geotextiles, Geomembranes and Related Products held May 28-June 1, 1990 at The Hague, the Netherlands[18], revealed that papers of direct interest to this study were on geotextiles related to aggregate surfaced pavements. A complete bibliography is contained in Appendix A. Personal and written communications that were made are included in Appendix B.

Details on the composition, materials, types, and manufacturing processing for geotextiles are not contained in this report. This information can be obtained from publications such as "Geotextile Engineering Manual,"[13] Designing with Geosynthetics,"[35] "Construction and Geotechnical Engineering Using Synthetic Fabrics,"[36] "Geotextile Design and Construction Guidelines,"[51] and manufacturers' product literature. Suggested test methods for determining properties and parameters for geotextile selection can be obtained from "Geotextile Engineering Manual"[13] and "Geotextile Design and Construction Guidelines".[51]

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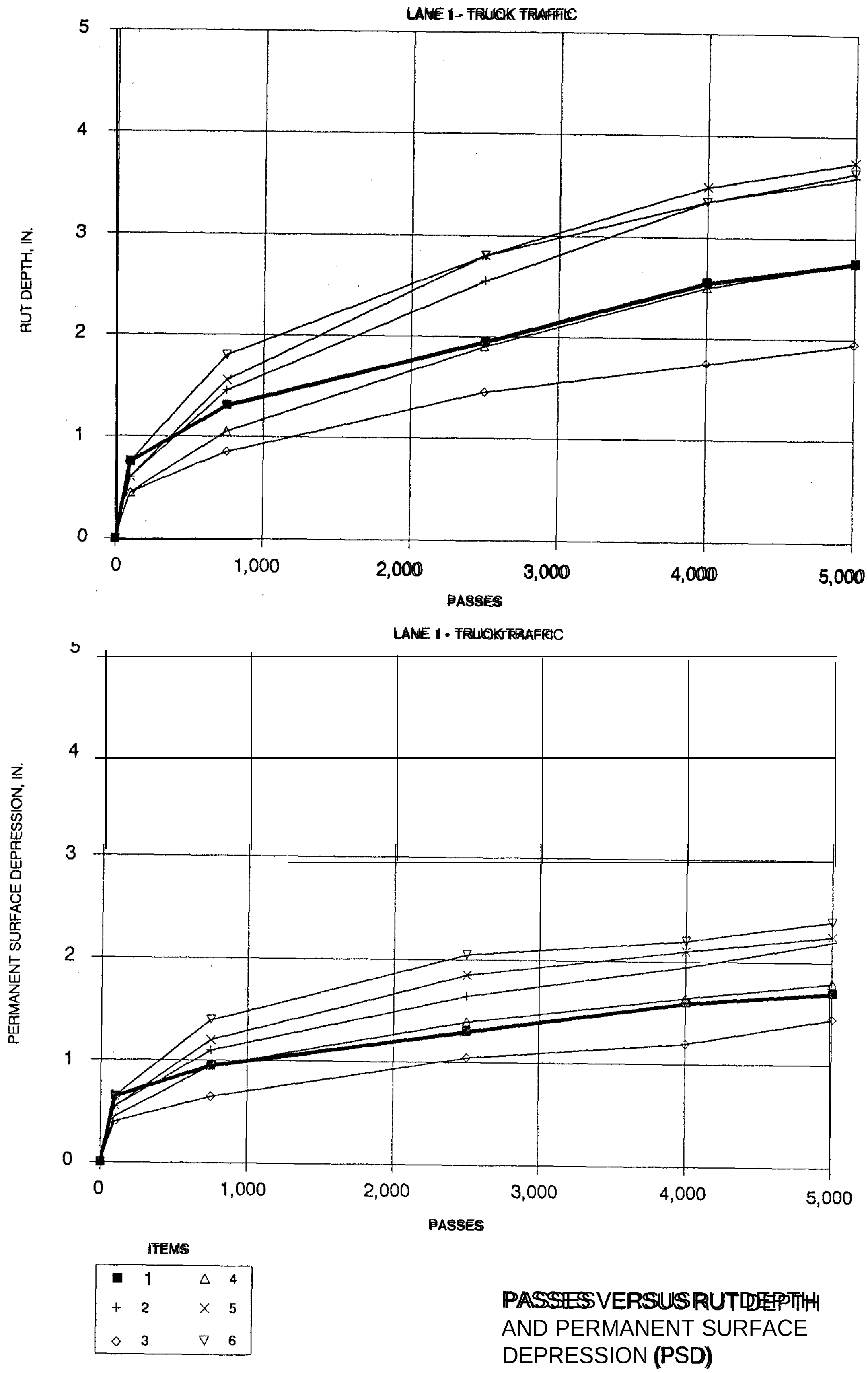
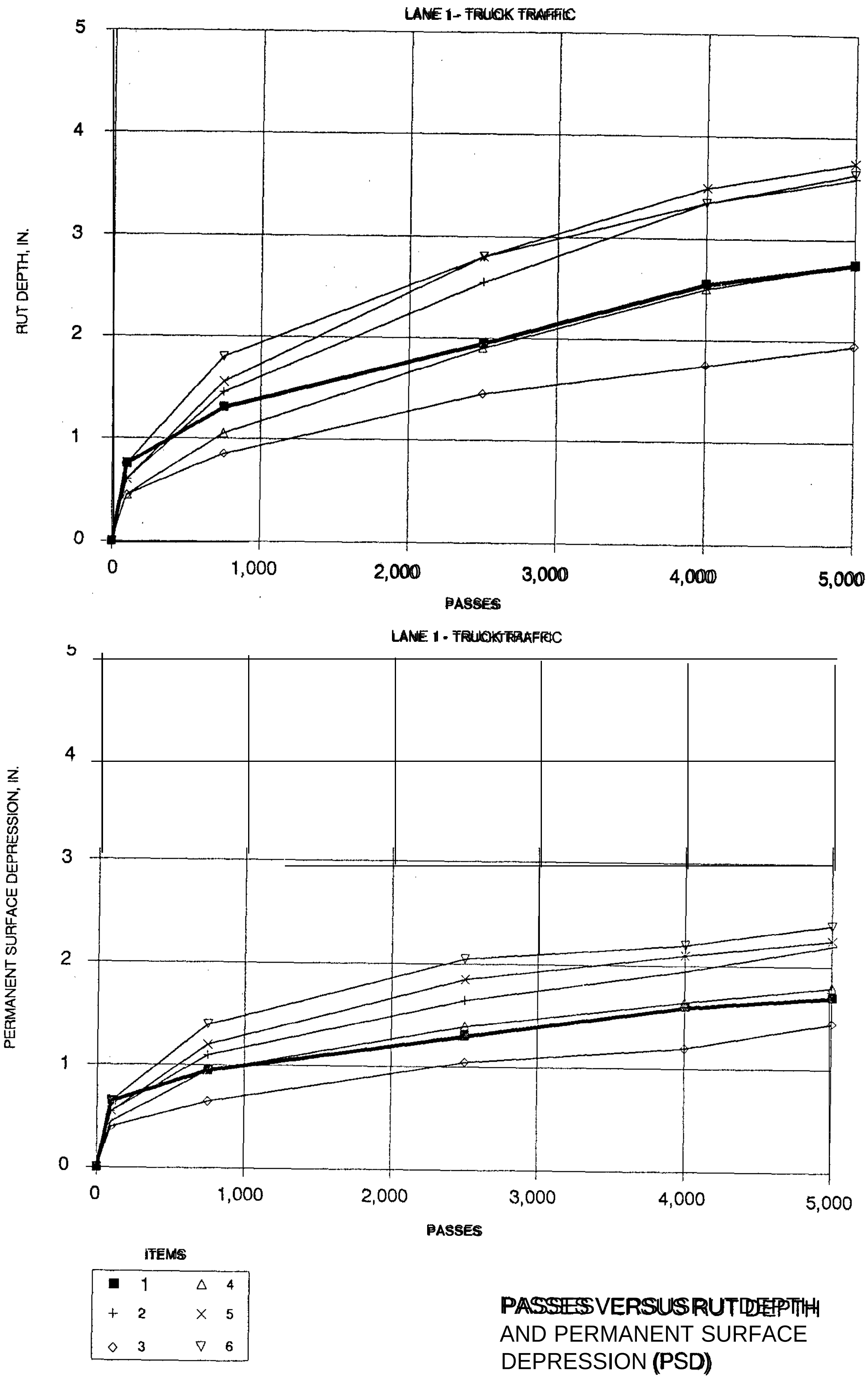


Figure 1. Truck traffic



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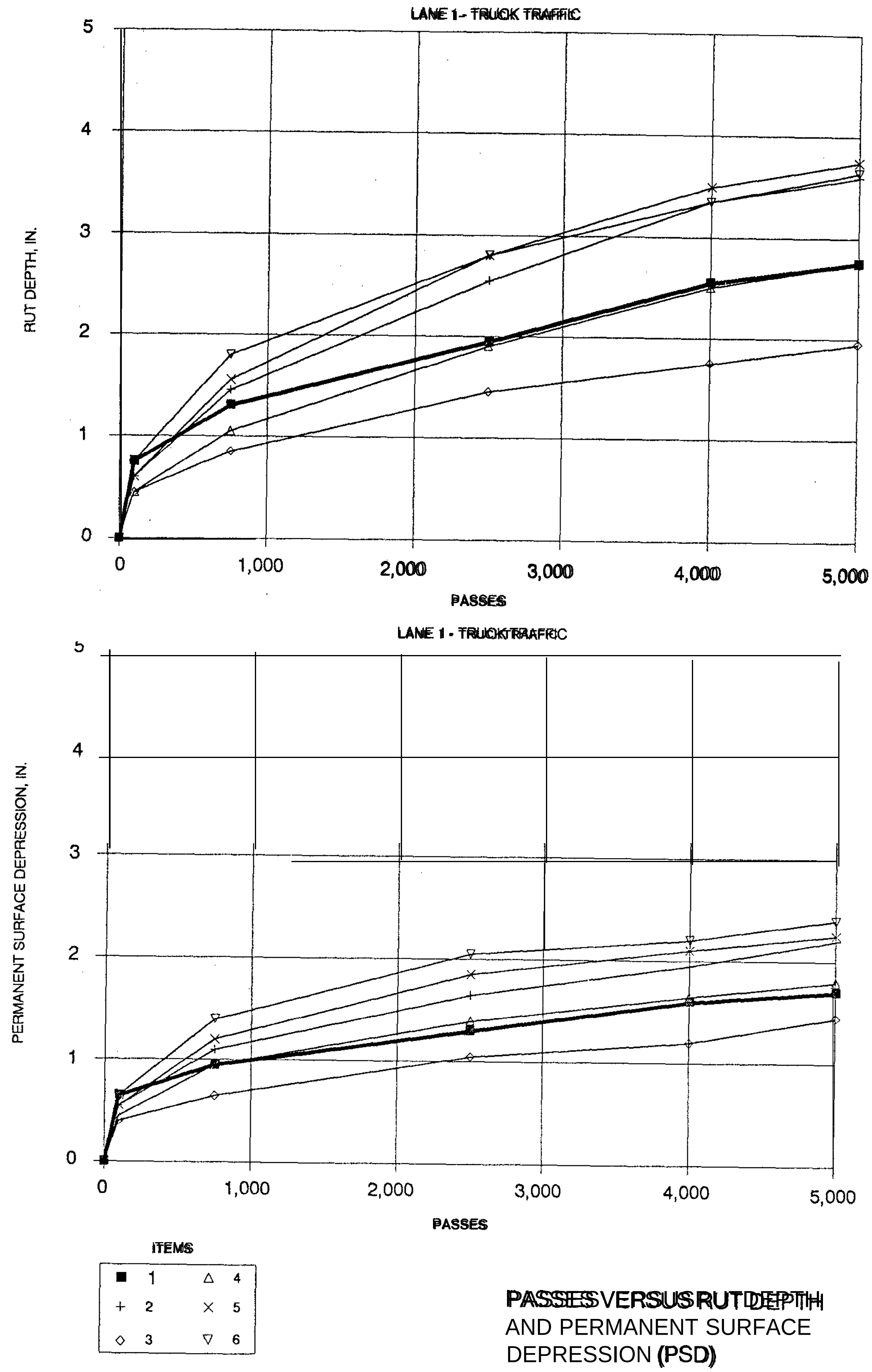

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all reinforcement items performed much worse than the control item. For a 3-in. rut, the reinforcement items handled only 100 to 200 passes, and the control item had 600 passes. Under tank traffic (Figure 3), performance was mixed. The geogrid (Item 3) performed best, followed by the two strongest geotextiles (Items 6 and 5), the control (Item 1), and then the two weaker geotextiles (Items 4 and 2). For all three types of traffic, test results showed that geogrids performed better than geotextiles. Results also showed that reinforcement material friction properties are critical to performance and that more work needs to be done regarding placement depths of reinforcement materials.

b. Geotextile Functions. Geotextiles that are used in aggregate surfaced pavements on soft subgrades usually fulfill one or more of the functions of separation, filtration, drainage, and reinforcement.[13,29,47,51] Information on these functions are given below.

(1) Separation. The separation function, which is considered by many[5,13,41,51] to be the primary function of geotextiles in road construction, prevents contamination of the coarse aggregate by intermixing with the subgrade soil, thus preserving the design. This intermixing occurs by either the aggregate being forced into the subgrade by the action of the applied loads or the migration of the subgrade into the aggregate layer. The load-spreading ability of the aggregate depends on continuous contact between individual pieces of aggregate. Under applied loads such as that from vehicle wheels, the aggregate layer deforms. After a sufficient quantity of load repetitions, the surface of the layer in contact with the subgrade begins to separate, since the individual pieces of aggregate cannot resist the tension forces. At the beginning, these separations are small; however, they become larger as the load repetitions continue. The subgrade enters the separations between individual aggregate pieces and soon the pieces "float" in the subgrade. The aggregate continuity, strength, and load spreading ability are reduced. The intermixing of the aggregate and subgrade continues until the aggregate bearing capacity is reduced to that of the subgrade. As little as 10 to 20 percent[18,43,44,46,47] intermixing of subgrade fines can completely destroy the strength of the aggregate layer. Thus, if bearing failure is prevented by the geotextile, then the subgrade should be capable of carrying the design load without distress or deterioration to the pavement system. However, localized bearing failures and subsequent subgrade/aggregate intermixing are only problems in weak soils (soils with California Bearing Ratio (CBR) values of less than 3).[13,50,51]

(2) Filtration. Filtration is the process of allowing water to easily escape from the soil while retaining the soil in place, thus preventing contamination of the aggregate layer and preserving its bearing capacity.

(3) Drainage. Drainage is the function of the geotextile which allows the water to rapidly escape from the pavement structure. This prevents water pressures from building up under loading conditions which could cause subgrade failure.

(4) Reinforcement. Reinforcement is strengthening of the pavement structure by including geotextile. This reinforcement[13,21,25,29] can be classified as base and subgrade restraint, lateral restraint, and membrane-type support. The geotextile tends to prevent the aggregate layer from

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(3) Prevention of contamination of the subbase materials which may allow more open-graded free draining aggregate to be considered for use.

(4) Reduction of the depth of excavation required for removal of unsuitable subgrade materials.

(5) Reduction of aggregate thickness required to stabilize the subgrade. Aggregate reduction in the structural design may or may not be considered.

(6) Less subgrade disturbance during construction.

(7) Maintaining integrity and uniformity of the pavement if settlement of the subgrade occurs. Settlement of subgrade is not prevented by the geotextile; however, its use can result in more uniform settlement.

(8) Reduction of maintenance and extended service life of pavement.

(9) Allows water to escape (drain) rapidly from the pavement structure which will prevent water pressures from building up under loading conditions that could cause subgrade failure.

d. Geotextile Properties and Criteria. Tables 1 and 2[7,13,51] list important geotextile properties that should be considered for constructability, durability, mechanical and hydraulic criteria for separation, and reinforcement applications, respectively. The properties listed in those tables cover the function of a geotextile mentioned in prior paragraphs. All of the properties listed in these tables may or may not be applicable in every application.

e. Geotextile Survivability. Geotextile survivability is defined as its resistance to destruction during placement and, after installation, the ability to perform the intended function throughout the design life. The required degree of survivability depends upon the subgrade condition, construction equipment, first construction lift thickness, cover material type, and construction equipment. Requirements for geotextile survivability as a function of subgrade condition and construction equipment and a function of cover material and construction equipment are presented in Tables 3 and 4[13,30,50], respectively.

The geotextile selection for either temporary or permanent roads is basically the same. For a correctly designed road system, the stress at the geotextile level due to aggregate weight and traffic should not be greater than the bearing capacity of the soil which is low (≤30 psi) where geotextiles are used. The stresses applied during construction may well be in excess of those applied to the geotextile during the design life. Therefore, the selection of the geotextile is governed usually by stresses anticipated during construction. However, in order for a geotextile to retain the desired properties after installation, it must be protected from construction damage such as tearing and puncturing.[9,29] Minimum strength guidelines required for the geotextiles to survive the most severe construction anticipated is found in Table 5[13,29,30,50,51]. Final specification selection should be based on specific site condition, experience, and judgment with the geotextile

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(5) Reduction of aggregate thickness required to stabilize the subgrade. Aggregate reduction in the structural design may or may not be considered.

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(7) Maintaining integrity and uniformity of the pavement if settlement of the subgrade occurs. Settlement of subgrade is not prevented by the geotextile; however, its use can result in more uniform settlement.

(8) Reduction of maintenance and extended service life of pavement.

(9) Allows water to escape (drain) rapidly from the pavement structure which will prevent water pressures from building up under loading conditions that could cause subgrade failure.

d. <u>Geotextile Properties and Criteria.</u> Tables 1 and 2[7,13,51] list important geotextile properties that should be considered for constructability, durability, mechanical and hydraulic criteria for separation, and reinforcement applications, respectively. The properties listed in those tables cover the function of a geotextile mentioned in prior paragraphs. All of the properties listed in these tables may or may not be applicable in every application.

e. <u>Geotextile Survivability.</u> Geotextile survivability is defined as its resistance to destruction during placement and, after installation, the ability to perform the intended function throughout the design life. The required degree of survivability depends upon the subgrade condition, construction equipment, first construction lift thickness, cover material type, and construction equipment. Requirements for geotextile survivability as a function of subgrade condition and construction equipment and a function of cover material and construction equipment are presented in Tables 3 and 4[13,30,50], respectively.

The geotextile selection for either temporary or permanent roads is basically the same. For a correctly designed road system, the stress at the geotextile level due to aggregate weight and traffic should not be greater than the bearing capacity of the soil which is low (<30 psi) where geotextiles are used. The stresses applied during construction may well be in excess of those applied to the geotextile during the design life. Therefore, the selection of the geotextile is governed usually by stresses anticipated during construction. However, in order for a geotextile to retain the desired properties after installation, it must be protected from construction damage such as tearing and puncturing.[9,29] Minimum strength guidelines required for the geotextiles to survive the most severe construction anticipated is found in Table 5[13,29,30,50,51]. Final specification selection should be based on specific site condition, experience, and judgment with the geotextile

(3) Prevention of contamination of the subbase materials which may allow more open-graded free draining aggregate to be considered for use.

(4) Reduction of the depth of excavation required for removal of unsuitable **subgrade** materials.

(5) Reduction of aggregate thickness required to stabilize the **sub**grade. Aggregate reduction in the structural design may or may not be considered.

(6) Less **subgrade** disturbance during construction.

(7) Maintaining integrity and uniformity of the pavement if settlement of the **subgrade** occurs. Settlement of **subgrade** is not prevented by the **geotextile**; however, its use can result in more uniform settlement.

(8) Reduction of maintenance and extended service life of pavement.

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Table 3

Geotextile Survivability as a Function of

Subgrade Conditions and Construction Equipment[13,30,50]

Subgrade Conditions	Construction Equipment and 6 to 12 in. Cover Material Initial Lift Thickness		
	Low Ground Pressure Equipment (≤4 psi)	Medium Ground Pressure Equipment (>4 psi, ≤8 psi)	High Ground Pressure Equipment (>8 psi)
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level such that any shallow depressions and humps do not exceed 6 in. in depth and height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low*	Moderate	High
Subgrade has been cleared of obstacles larger than small- to moderate-sized tree limbs and rocks. Tree trunks should be removed or covered with a partial working table. Depressions and humps should not exceed 18 in. in depth and height. Larger depressions should be filled.	Moderate	High	Very High
Minimal site preparation is required. Trees may be cut, delimbed, and left in place. Stumps should be cut to project not more than 6 in. ± above subgrade. Fabric may be draped directly over the tree trunks, stumps, large depressions and humps, holes, stream channels, and large boulders.	High	Very High	Not Recommended

Note:

1. Recommendations are for 6 to 12 in. initial lift thickness. For other initial lift thicknesses:
   - 12 to 18 in.: Reduce survivability requirement 1 level
   - 18 to 24 in.: Reduce survivability requirement 2 levels
   - > 24 in.: Reduce survivability requirement 3 levels

   Survivability levels are, in increasing order: low, moderate, high, and very high.
2. For special construction techniques such as prerutting, one should increase fabric survivability requirement 1 level.
3. Placement of excessive initial cover material thickness may cause bearing failure of soft subgrades.

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survivability verified for major projects by conducting field tests under site specific conditions.

f. Geotextile Installation Guidelines.[13,51] The successful use of geotextiles in road construction requires proper installation. Although the installation techniques appear fairly simple, a majority of the problems with geotextiles in roads have occurred as the result of improper construction techniques. If the geotextile is ripped or punctured during construction activities, it will not likely perform as desired. If the geotextile is placed with a lot of wrinkles or folds, it will not be tensioned, and therefore will not provide any reinforcing effect. Other problems occur due to insufficient cover over the fabric, rutting of the subgrade prior to placing the fabric, and placing lift thicknesses such that the bearing capacity of the soil is exceeded. The following step-by-step procedures should be followed, along with engineering monitoring of all construction activities.

(1) The site should be cleared, grubbed, and excavated to design grade, taking care to strip all top soil, soft soils, or any other unsuitable materials. If moderate site conditions exist, i.e., CBR greater than 1, lightweight proofrolling operations should be considered to aid in locating unsuitable materials to be removed. Isolated pockets where overexcavation is required should be graded and backfilled so as to promote positive drainage. Optionally, special drain tiles with outlets installed to drain these isolated areas could be used.

(2) During stripping operations, care should be taken not to disturb the subgrade. This may require the use of lightweight dozers or grade-alls for low strength, saturated noncohesive and low cohesive soils. For extremely soft ground, such as peat bog areas, consideration should be given not to overexcavate the surface materials such that advantage can be taken of the root mat, if it exists. In this case, all vegetation should be cut off square at the ground surface. Sawdust or sand can be placed over stumps or roots that extend above the ground surface to cushion the geotextile. The subgrade preparation must correspond to the survivability properties of the geotextile.

(3) Once the subgrade along a particular segment of the road alignment has been prepared, the geotextile should be rolled in line with the placement of the new road aggregate. Field operations can be expedited if the geotextile is presewn in the factory to design widths such that it can be unrolled in one continuous sheet. The geotextile should not be dragged across the subgrade. The entire roll should be placed and rolled out as smoothly as possible. Wrinkles and folds in the geotextile should be removed by stretching and staking as required.

(4) Parallel rolls of geotextiles should be overlapped, sewn, or tied as required. Specific requirements are given later.

(5) For curves, the geotextile should be folded or cut and overlapped in the direction of the turn. Folds in the geotextile should be stapled or pinned 5 ft on center.

(6) When the geotextile intersects an existing pavement area, the material should extend to the edge of the old system. For widening or

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(6) When the geotextile intersects an existing pavement area, the material should extend to the edge of the old system. For widening or

case should ruts be bladed down as this would decrease the amount of aggregate cover between the ruts.

(14) All remaining subbase aggregate should be placed in lifts not exceeding 9 in. in loose thickness and compacted to the appropriate specification density.

g. Overlaps.[13,51] Overlaps can be used to provide continuity between adjacent geotextile sections through frictional resistance between the overlaps. A sufficient overlap is required to prevent soil from squeezing into the aggregate at the geotextile joint. The amount of overlap depends primarily on the soil conditions and the potential for equipment to rut the soil. If the subgrade will not rut under construction activities, only a minimum overlap sufficient to provide some pullout resistance is required. As the potential for rutting and squeezing of soil increases, the required overlap increases. Since rutting potential can be related to soil strength (CBR), it can be used as a guideline for the minimum overlap required, as shown in Table 6.

Table 6

Recommended Minimum Overlap Requirements

CBR	Minimum Overlap
Greater than 2	1 - 1.5 ft
1 - 2	2 - 3 ft
0.5 - 1	3 ft or sewn
Less than 0.5	Sewn
All roll ends	3 ft or sewn

The geotextile can be stapled or pinned at the overlaps to maintain them during construction activities. The 10- to 12-in.-long nails should be placed at a minimum of 50 ft on centers for parallel rolls and 5 ft on centers for roll ends.

Fabric widths should be selected such that overlaps of parallel rolls occur at the center line and at the shoulder. Overlaps should not be placed along anticipated main wheel path locations.

Overlaps at the end of rolls should be in the direction of the aggregate placement (previous roll on top).

h. Seams. When seams are required for separation applications, it is recommended that the seams meet the same tensile strength requirements for survivability as required for the geotextile (Table 5) in the direction perpendicular to the seam (as determined by the same testing methods). All factory or field seams should be sewn with thread having the same or greater durability and strength as the material in the geotextile. "J-seams" case should ruts be bladed down as this would decrease the amount of aggregate cover between the ruts.

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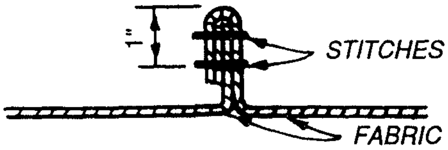
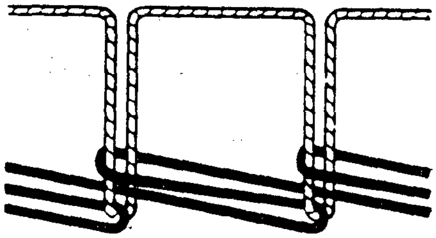
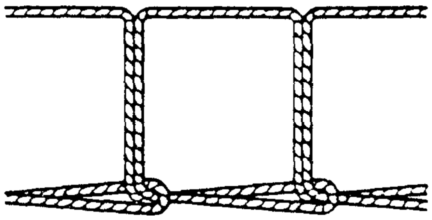


"J" SEAM
(TYPE SSN-2)*



DIRECTION OF SUCCESSIVE STITCH FORMATION

DOUBLE THREAD
CHAIN OR "LOCK" STITCH
(TYPE 401)



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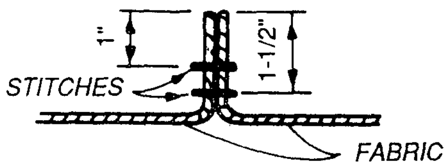
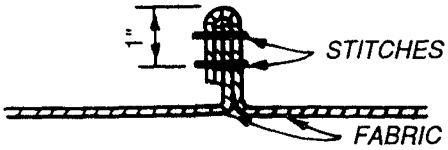
SINGLE THREAD
CHAIN STITCH
(TYPE 101)*



"FLAT" OR "PRAYER SEAM
(TYPE SSA-2)*

*TYPES PER FED-STD-751 A(48)

Figure 4. Stitch and seam types



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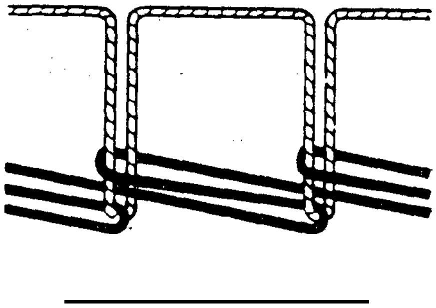

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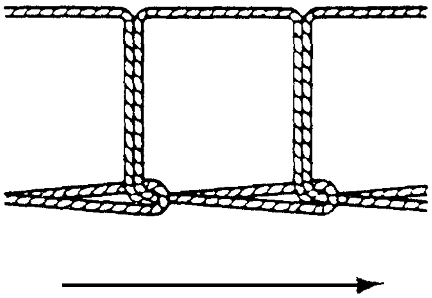

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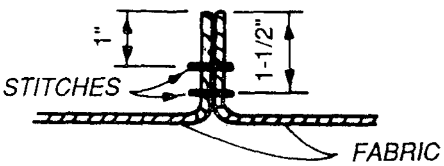

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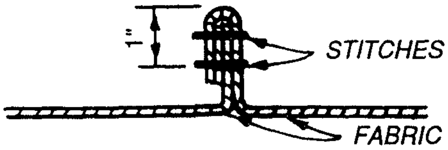

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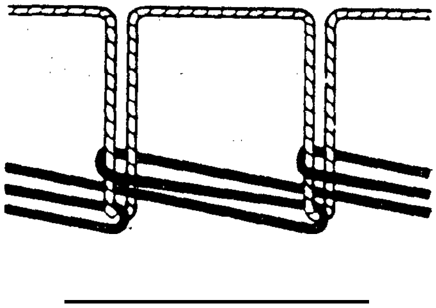

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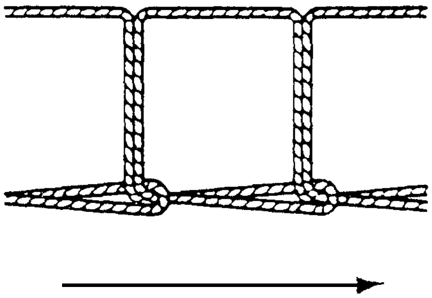

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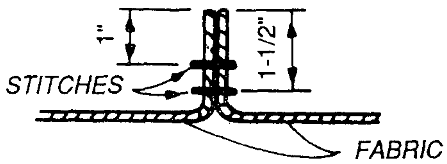

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FLEXIBLE PAVEMENTS FOR ROADS

Review of the information obtained from the various sources in this literature search revealed that some research has been conducted on the use of geotextiles in flexible pavement for road construction. Much of the work has been limited to small laboratory studies with little published information on full-scale field and/or long-term investigations. There are various standard design procedures for flexible and rigid pavements available; however, they do not include the use of geotextiles. This study revealed that there are design guidelines and procedures available where geotextiles are considered for flexible pavement road construction. Some of these procedures will be mentioned; however, details are not given in this report but can be obtained from the respective references. A brief summary on the most comprehensive work to date on geosynthetic (geogrid or geotextile) use in base courses for flexible pavements is given below along with other items related to geotextile usage that are considered to be important.

a. Geosynthetic Use In Flexible Pavements. The most comprehensive work to date on geosynthetic (geogrid or geotextile) reinforcement for base courses for flexible pavements was conducted by Barksdale, Brown, and Chan.[4,12] The laboratory research was conducted at the University of Nottingham, and the analytical studies were conducted at the Georgia Institute of Technology.

Variables investigated in the laboratory study included the following:

(1) Type and Stiffness of Reinforcement (geogrids and high modulus woven geotextiles).

(2) Reinforcement Position.

(3) Pavement Strength.

(4) Geosynthetic Prestressing.

(5) Prerutting of the Aggregate Base both with and without Reinforcement.

The laboratory tests consisted of a 1.0- to 1.5-in.-thick asphalt surfacing placed over a 6- or 8-in.-thick aggregate base. The silty clay subgrade had a CBR of 2.5. A 1,500-lb moving wheel load was employed in the experiments.

(1) Results. The laboratory and analytical results indicated that geosynthetic reinforcement of an aggregate base can, under the proper conditions, improve pavement performance with respect to both permanent deformation and fatigue. Specific conclusions from the study are as follows:

(a) Type and Stiffness of Geosynthetic. A geogrid having an open mesh has the reinforcing capability of a woven geotextile having a stiffness approximately two and one-half times as great as the geogrid. A geogrid performs differently than a geotextile. Test results indicate that the minimum stiffness to be used for aggregate reinforcement applications should be 1,500 lb/in. for geogrids and 4,000 lb/in. for woven geotextiles.

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FLEXIBLE PAVEMENTS FOR ROADS

Review of the information obtained from the various sources in this literature search revealed that some research has been conducted on the use of geotextiles in flexible pavement for road construction. Much of the work has been limited to small laboratory studies with little published information on full-scale field and/or long-term investigations. There are various standard design procedures for flexible and rigid pavements available; however, they do not include the use of geotextiles. This study revealed that there are design guidelines and procedures available where geotextiles are considered for flexible pavement road construction. Some of these procedures will be mentioned; however, details are not given in this report but can be obtained from the respective references. A brief summary on the most comprehensive work to date on geosynthetic (geogrid or geotextile) use in base courses for flexible pavements is given below along with other items related to geotextile usage that are considered to be important.

a. Geosynthetic Use In Flexible Pavements. The most comprehensive work to date on geosynthetic (geogrid or geotextile) reinforcement for base courses for flexible pavements was conducted by Barksdale, Brown, and Chan.[4,112] The laboratory research was conducted at the University of Nottingham, and the analytical studies were conducted at the Georgia Institute of Technology.

Variables investigated in the laboratory study included the following:

(1) Type and Stiffness of Reinforcement (geogrids and high modulus woven geotextiles).

(2) Reinforcement Position.

(3) Pavement Strength.

(4) Geosynthetic Prestressing.

(5) Prerutting of the Aggregate Base both with and without Reinforcement.

The laboratory tests consisted of a 1.0- to 1.5-in.-thick asphalt surfacing placed over a 6- or 8-in.-thick aggregate base. The silty clay subgrade had a CBR of 2.5. A 1,500-lb moving wheel load was employed in the experiments.

(1) Results. The laboratory and analytical results indicated that geosynthetic reinforcement of an aggregate base can, under the proper conditions, improve pavement performance with respect to both permanent deformation and fatigue. Specific conclusions from the study are as follows:

(a) Type and Stiffness of Geosynthetic. A geogrid having an open mesh has the reinforcing capability of a woven geotextile having a stiffness approximately two and one-half times as great as the geogrid. A geogrid performs differently than a geotextile. Test results indicate that the minimum stiffness to be used for aggregate reinforcement applications should be 1,500 lb/in. for geogrids and 4,000 lb/in. for woven geotextiles.

AGGREGATE SURFACED AIRFIELDS[53]

In 1987 Webster[53] worked with US Army troops of the 52nd Engineer Battalion and designed an aggregate-geotextile C-130 airfield for the Army's Pinon Canyon Maneuver Site near Trinidad, Colorado. The subgrade was a silty clay soil with a design soaked CBR of 2.9. The design was completed using the Exxon 1 computer program.[16] This program is based on the US Army Corps of Engineer's unsurfaced thickness criteria[28] and Giroud's and Noiray's design[23] for geotextile reinforcement. The final design for the 125-kip C-130 aircraft was 10 in. of crushed stone base course over a geotextile with a grab strength of 270 lb (see Table 5). The 60-ft-wide by 5,000-ft-long runway was constructed in March of 1987. Based on its good performance, a parallel taxiway and parking aprons were added in 1989, using the same type aggregate-geotextile design procedure.

In August 1988 Webster[53] designed a second aggregate-geotextile C-130 runway, and the 52nd Engineer Battalion constructed the runway at Fort Carson, Colorado. This runway replaced the existing Red Devil clay airstrip. The existing airstrip could not be used during wet weather and required substantial maintenance due to rutting and erosion of the clay subgrade soil. The existing airstrip was reconstructed into a 60-ft-wide by 5,000-ft-long runway consisting of 8 in. of crushed aggregate over a geotextile meeting the same requirements as above. In all three construction projects, a slit-film woven geotextile was delivered as the lowest cost geotextile meeting the grab strength requirements.

No problems were encountered during construction of these airfields. Both airfield facilities have performed as designed.

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No problems were encountered during construction of these airfields. Both airfield facilities have performed as designed.

Messrs. B. Clark and D. Jones* revealed that the runway extension was completed as planned. However, the extension was added only as an emergency overrun and was not paved for aircraft traffic. The extension which is covered with natural grass has been used only twice by aircraft since installation. No major aircraft, property damage, or loss of life occurred during the overruns. There has been minor settlement around pilings that were installed on the extension for attachment of airfield lighting. The pilings were installed through the geotextile fabric.

The article by Gale and Henderson[19] is another "Case History" given in the Summer 1984 issue of Geotechnical Fabrics Report. This project involved extending the taxiway system 2,000 ft to one end of the main runway at the Duluth International Airport, Duluth, MN. The 2,000 ft of taxiway extension was over swamp deposited peat soil which ranged in depth from 8 to 10 ft. The grade of the swamp had to be raised from 7 to 10 ft in order to tie in with the existing taxiway pavement. Several construction schemes were considered, however, the decision was made to place a woven geotextile, then stage loading of fill with a final surcharge. It was critical that settlement of the peat be kept to a minimum after placement of the pavement. To achieve this, an additional 6 ft fill (surcharge) was placed above the proposed pavement surface. The fill placement was completed in November 1983. Settlement measurements made in June 1984 ranged from 3 to 4 ft which was in the predicted range. Gale and Henderson's article covered only the planned action for the spring of 1985. However, conversation with Messrs. Stephen Gale and Ken Wennberg** revealed the surcharge was removed in the spring of 1985. Final grade preparation and paving of the taxiway were completed during the summer of 1985. This paved taxiway has performed satisfactory without any problems to date.

a. Pertinent Items. The functions of geotextiles presented in the "Flexible Pavements for Roads" section of this report should be evaluated when considering the use of geotextiles in airport pavement construction. However, the need for the geotextile to perform as a separator may not be applicable in airport construction. As previously mentioned in the "Aggregate Surfaced Pavements" and "Flexible Pavements for Roads" sections of this report, the need for a geotextile to provide the separation function exists only when the strength of the subgrade is less than 3 CBR. Flexible pavement design curves in Federal Aviation Administration (FAA) Advisory Circular 150/5320-6C[49] for aircraft up to 30,000 lb gross weight (Figure 5) list the lower strength value of the subgrade to be approximately 3.5 CBR. Similar curves for aircraft over 30,000 lb gross weight (Figure 6) list the lower strength value of the subgrade to be 3 CBR. The potential benefits of using geotextiles for aggregate surfaced pavements and flexible pavements for roads should be investigated when considering geotextiles. The geotextile properties and criteria (Table 1), survivability properties, and characteristics and installation guidelines presented in the "Aggregate Surfaced Pavements" section should be

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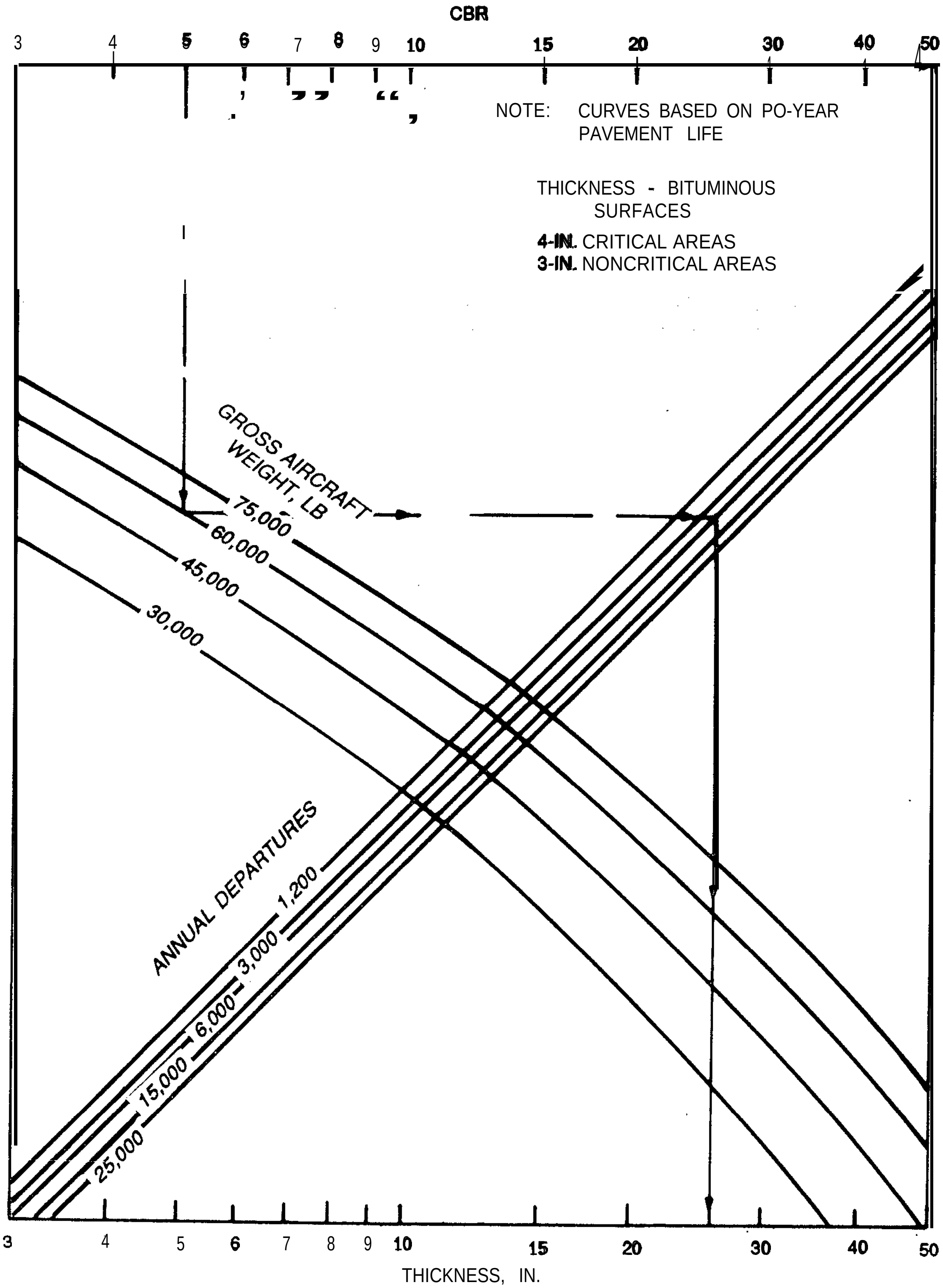


Figure 6. Flexible pavement design curves for critical areas, single wheel gear[49]

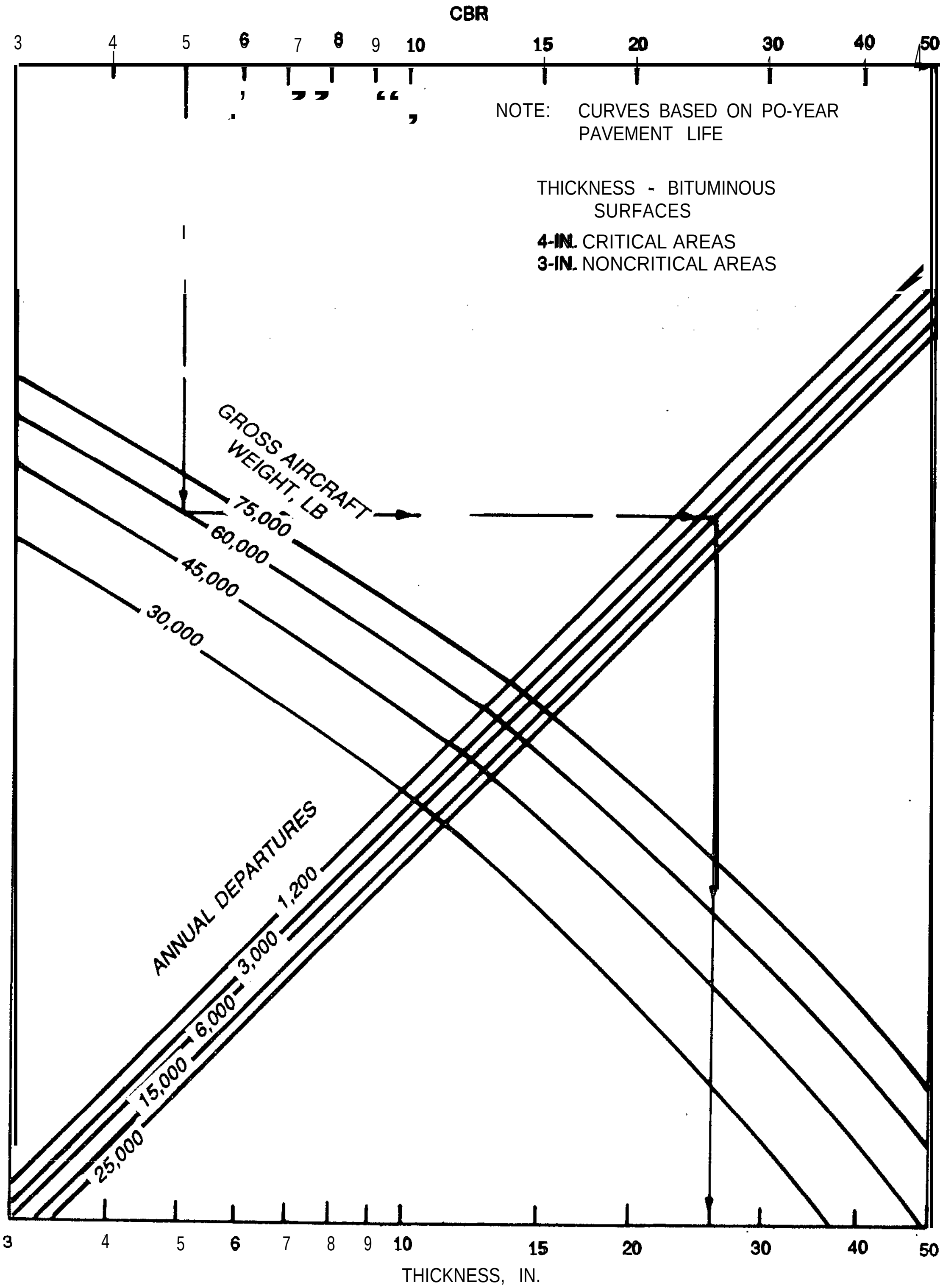
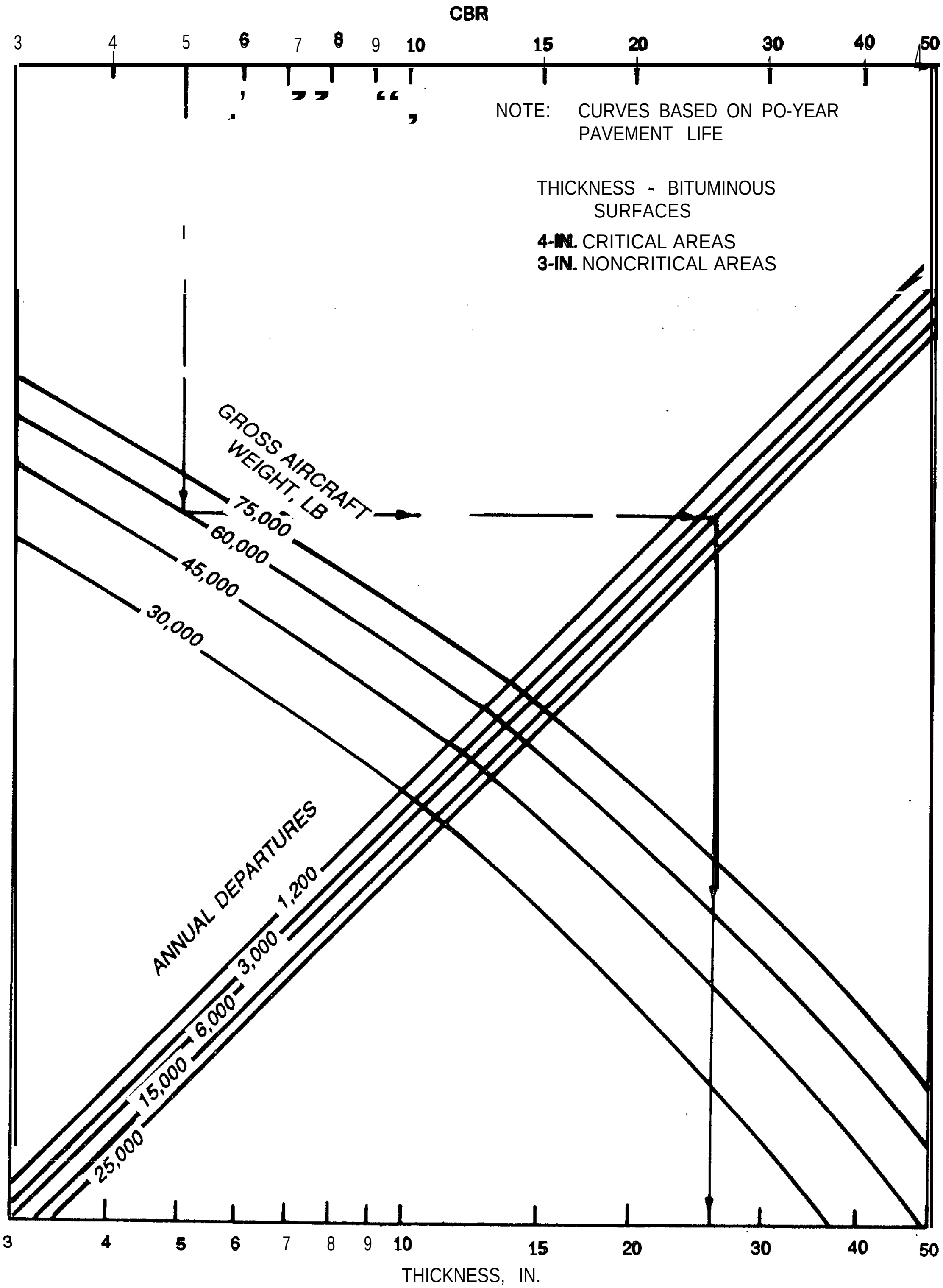


Figure 6. Flexible pavement design curves for critical areas, single wheel gear(49)



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RECOMMENDATIONS

The use of current standard airport design procedures should be continued without any structural support attributed to the geotextiles, if they are used, until such time design procedures incorporating geotextiles are developed. Geotextiles should be considered only for site specific situations such as:

a. When the subgrade strength is $\leq$ 3 CBR, geotextiles should be used to aid in establishing a stable foundation layer on which to construct a pavement system.

b. On known problem subgrades subject to rutting even when recommended FAA design thicknesses are used.

Further research should be delayed on the use of geotextiles to improve subgrade support for general aviation airports until the results of the laboratory grid study (Phase I, Task 4) and field grid tests (Phase I, Task 5) are known.

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18. "Fourth International Conference on Geotextiles," Jan/Feb 1990. Geomembranes and Related Products, Geotechnical Fabrics Report, Vol 8, No. 1, pp 49-56.

19. Gale, S. M., and Henderson, J. S. 1984 (Summer). "Design and Construction of a Geotextile Reinforced Taxiway Embankment Over Peat," Geotechnical Fabrics Report, Vol 2, No. 1, pp 7-11.

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21. __________ . 1987. "Tomorrow's Designs for Geotextile Applications," Geotextile Testing and the Design Engineer, ASTM STP 952, pp 69-116, J. E. Fluet, Jr., Editor, American Society for Testing and Materials, Philadelphia, PA.

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23. Giroud, J. P., and Noiray, L. 1981. "Geotextile-Reinforced Unpaved Road Design," Journal of the Geotechnical Engineering Division, American Society of Civil Engineers. Vol 107, No. GT9, pp 1,233-1,254.

24. "Guidelines for Design of Flexible Pavements Using Mirafi® Woven Geotextiles." 1982. Mirafi, Inc., Charlotte, NC (® Mirafi is a trademark owned by Mirafi, Inc.).

25. Haliburton, T. A., and Barron, J. V. 1983. "Optimum Method for Design of Fabric-Reinforced Unsurfaced Roads," Transportation Research Record 916, pp 26-32, Transportation Research Board, Washington, DC.

26. Haliburton, T. A., Lawmaster, J. D., and King, J. K. 1980. "Potential Use of Geotechnical Fabric In Airfield Runway Design," Oklahoma State University, Stillwater, Oklahoma for US Air Force, Bolling AFB, Washington, DC.

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55. Webster, S. L., and Alford, S. J. 1978. "Investigation of Construction Concepts for Pavements Across Soft Grounds," Technical Report S-78-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

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Christopher, B. R., and Holtz, R. D. 1985 (Mar). "Geotextile Engineering Manual," Report FHWA-TS-86/203, STS Consultants, Ltd, Northbrook, IL, for Federal Highway Administration, Washington, DC.

Collios, A., Delmas, P., Gourc, J. P., and Giroud, J. P. 1980 (Apr). "Experiments on Soil Reinforcement with Geotextiles," Proceedings of American Society of Civil Engineers Convention, Portland, OR.

Department of Defense. 1983. "Stitches, Seams and Stitching," Federal Standard 751A with Change Notice 1, Washington, DC.

Deutscheim, E. A., and Sutherland, M. R. 1987 (May). "Geotextile Reinforced Bitumen Seal on an Expansive Clay Road Pavement," Engineering Conference Darwin. pp 15-19, Australia.

"Exxon Geotextile Design Manual for Paved and Unpaved Roads." 1985. Prepared by J. P. Fluet, GeoServices, Inc. for Exxon Chemical Americas, Houston, TX.

"Fabrics Build Better Roads." 1979 (Oct). Better Roads, Vol 49, No. 10, pp 8-11.

Floss, R. 1985. "Geotextiles in Soil Mechanics and Foundation Engineering; A Report on the First German Symposium on Geotextiles," Geotextiles and Geomembranes. Vol 2, No. 4, Elsevier Applied Science Publishers, pp 337-355, Ltd, England.

"Fourth International Conference on Geotextiles, Geomembranes, and Related Products." 1990 (Jan/Feb). Geotechnical Fabrics Report, Vol 8, No. 1, pp 49-56.

"Geotextiles' Construction Role Grows Rapidly." 1986 (Jul). World Construction. pp 41-46.

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Headquarters, Department of the Army. 1990 (draft). "Engineering Use of Geotextiles," TM 5-818-8, Washington, DC.

Holtz, R. D., and Harr, M. E. 1983 (Oct). "Analytical and Experimental Investigation of Soil Reinforcing," Report No. ESL-TR-82-31, Purdue University, West Lafayette, IN for Tyndall AFB, FL.

Koerner, R. M. 1990. "Designing with Geosynthetics," Prentice Hall, Englewood Cliffs, NJ.

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Department of Defense. 1983. "Stitches, Seams and Stitching," Federal Standard 751A with Change Notice 1, Washington, DC.

Deutschein, E. A., and Sutherland, M. R. 1987 (May). "Geotextile Reinforced Bitumen Seal on an Expansive Clay Road Pavement," Engineering Conference Darwin. pp 15-19, Australia.

"Exxon Geotextile Design Manual for Paved and Unpaved Roads." 1985. Prepared by J. P. Fluet, GeoServices, Inc. for Exxon Chemical Americas, Houston, TX.

"Fabrics Build Better Roads." 1979 (Oct). Better Roads, Vol 49, No. 10, pp 8-11.

Floss, R. 1985. "Geotextiles in Soil Mechanics and Foundation Engineering; A Report on the First German Symposium on Geotextiles," Geotextiles and Geomembranes. Vol 2, No. 4, Elsevier Applied Science Publishers, pp 337-355, Ltd, England.

"Fourth International Conference on Geotextiles, Geomembranes, and Related Products." 1990 (Jan/Feb). Geotechnical Fabrics Report, Vol 8, No. 1, pp 49-56.

"Geotextiles' Construction Role Grows Rapidly." 1986 (Jul). World Construction. pp 41-46.

Giroud, J. P. 1986 (Nov/Dec). "Geotextiles: The Road Ahead," Civil Engineering Supplement. Geotextiles and Geomembranes, pp 3-5, England.

Headquarters, Department of the Army. 1990 (draft). "Engineering Use of Geotextiles," TM 5-818-8, Washington, DC.

Holtz, R. D., and Harr, M. E. 1983 (Oct). "Analytical and Experimental Investigation of Soil Reinforcing," Report No. ESL-TR-82-31, Purdue University, West Lafayette, IN for Tyndall AFB, FL.

Koerner, R. M. 1990. "Designing with Geosynthetics," Prentice Hall, Englewood Cliffs, NJ.

Majidzadeh, K., Luther, M. S., and Skylut, H. 1982. "A Mechanistic Design Procedure For Fabric-Reinforced Pavement Systems," Second International Conference on Geotextiles, Vol II, pp 529-534, Las Vegas, NV.

Perfetti, J., and Sangster, T. 1989. "The Function of Geotextiles in Pavement Structures," Geosynthetics '89 Conference, pp 334-344, San Diego, CA.

Puffer, W. G., 1981 (May). "Engineering Fabrics Used on New York Highways," Civil Engineering, pp 61-63.

Sequerth, J. 1987 (Jan). "Improving Roads with Geotextiles," American City and Country, Vol 102, No. 1, pp 28-32.

Sprague, C. J., and Cicoff, G. 1989 (Feb). "A Study of Permanent Road Stabilization: Low-Cost Pavemet Structures and Lightweight Geotextiles," Geosynthetics '89 Conference Proceedings, pp 316-323, San Diego, CA.

UNPAVED ROADS

Barenberg, E. H., Dowland, J. H, Jr., and Hales, J. H. Aug 1975. "Final Report on Evaluation of Soil-Aggregate Systems with Mirafi Fabric," University of Illinois, Urbana, IL.

Bell, J. R. 1980 (Sept). "Design Criteria for Selected Geotextile Installations," Proceedings of the First Canadian Symposium on Geotextiles, pp 35-37, Calgary, Alberta.

Bell, J. R. 1980. "Geotextiles for Soil Improvement," Proceedings of the American Society of Civil Engineers National Convention, pp 1-30, Portland, OR.

Bender, D. A., and Barenberg, E. J. 1978. "Design and Behavior of Soil-Fabric Aggregate Systems," Transportation Research Record 671, Transportation Research Board, Washington, DC.

Bonaparte, R., Ah-Line, A. M., Charron, R., and Tisinger, L. 1988. "Survivability and Durability of a Nonwoven Geotextile," Proceedings of Symposium on Geosynthetics for Soil Improvement, pp 68-91, American Society of Civil Engineers National Convention, Nashville, TN.

Cook, M. J., and Kennedy, R. A. 1988. "Use of Fabric in Forest Road Construction," Thirty Fourth Annual Road Builders Clinic Proceedings, pp 37-41, Pullman, WA.

DeGroat, M., Janse, E., Maagenberg, T. A. C., and Van Den Berg, C. 1986. "Design Method and Guidelines for Geotextile Application in Road Construction," Proceedings on Third International Conference on Geotextiles, pp 741-746, Vienna, Austria.

"Design Guidelines and Installation Procedures Using Mirafi® 600X and 500X for Unpaved Road and Area Stabilization." 1989 (Feb). Mirafi, Inc, Charlotte, NC (® Mirafi is a trademark owned by Mirafi, Inc.).

Majidzadeh, K., Luther, M. S., and Skylut, H. 1982. "A Mechanistic Design Procedure For Fabric-Reinforced Pavement Systems," Second International Conference on Geotextiles, Vol II, pp 529-534, Las Vegas, NV.

Perfetti, J., and Sangster, T. 1989. "The Function of Geotextiles in Pavement Structures," Geosynthetics '89 Conference, pp 334-344, San Diego, CA.

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Sequerth, J. 1987 (Jan). "Improving Roads with Geotextiles," American City and Country, Vol 102, No. 1, pp 28-32.

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Bell, J. R. 1980 (Sept). "Design Criteria for Selected Geotextile Installations," Proceedings of the First Canadian Symposium on Geotextiles, pp 35-37, Calgary, Alberta.

Bell, J. R. 1980. "Geotextiles for Soil Improvement," Proceedings of the American Society of Civil Engineers National Convention, pp 1-30, Portland, OR.

Bender, D. A., and Barenberg, E. J. 1978. "Design and Behavior of Soil-Fabric Aggregate Systems," Transportation Research Record 671, Transportation Research Board, Washington, DC.

Bonaparte, R., Ah-Line, A. M., Charron, R., and Tisinger, L. 1988. "Survivability and Durability of a Nonwoven Geotextile," Proceedings of Symposium on Geosynthetics for Soil Improvement, pp 68-91, American Society of Civil Engineers National Convention, Nashville, TN.

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DeGroat, M., Janse, E., Maagenberg, T. A. C., and Van Den Berg, C. 1986. "Design Method and Guidelines for Geotextile Application in Road Construction," Proceedings on Third International Conference on Geotextiles, pp 741-746, Vienna, Austria.

"Design Guidelines and Installation Procedures Using Mirafi® 600X and 500X for Unpaved Road and Area Stabilization." 1989 (Feb). Mirafi, Inc, Charlotte, NC (® Mirafi is a trademark owned by Mirafi, Inc.).

Kinney, T. C., and Barenberg, E. J. 1982. "The Strengthening Effect of Geotextiles on Soil-Geotextile-Aggregate Systems," Second International Conference on Geotextiles, Vol II, pp 381-386, Las Vegas, NV.

Koerner, R. M., and Welsh, J. P. 1980. "Construction and Geotechnical Engineering Using Synthetic Fabrics," Supplementary Course Notes for American Society of Civil Engineering Continuing Education Course.

Laier, H., and Brau, G. 1986. "The Use of Geotextiles in Road Construction Under Intensive Dynamic Loading," Proceedings on Third International Conference on Geotextiles, pp 995-1000, Vienna, Austria.

Mohney, J. W., and Steward, J. E. 1982. "Construction and Evaluation of Roads Over Low Strength Soils Using Nonwoven Geotextiles," Proceedings of the Nineteenth Engineering Geology and Soils Engineering Symposium, pp 161-180, Pocatello, ID.

Pease, G. D. 1989. "Rocks over Troubled Waters: A Floating Road for Tanks," Engineer, Vol 19, PB 5-89-3/4, pp 22-25, Ft. Leonard Wood, MO.

Puffer, W. G. 1982. "Nonwoven Engineering Fabrics in Road Construction on Soft Soils," 10th Technical Symposium, Advances in Nonwoven Technology, pp 382-392, NY.

"Road Base and Construction Site Stabilization Using Aggregate and Geotextiles." 1984 (Jan). Better Roads, No. 1, Vol 54, pp 8-12.

Robnett, Q. L., and Lai, J. S. 1982. "Effect of Fabric Properties on the Performance and Design of Aggregate-Fabric-Soil Systems," Second International Conference on Geotextiles, Vol II, pp 381-386, Las Vegas, NV.

Robnett, Q. L., and Lai, J. S. 1982. "Fabric-Reinforced Aggregate Roads-Overview," Transportation Research Record 875, pp 42-50, Transportation Research Board, Washington, DC.

Ruddock, E. C., Potter, J. F., and McAvoy, A. R. 1986. "The Construction and Performance under Traffic of a Full-Scale Experimental Road Incorporating Geotextiles," CIRIA Technical Note 126, Construction Industry Research Association, London, England.

Schauz, W. G. 1981. "Performance of Fabric Reinforced Aggregate-Soil Systems Under Repeated Loading," Georgia Institute of Technology.

Sellmeijer, J. B., Kenter, C. J., and Van Den Berg, C. 1982. "Calculation Method for a Fabric Reinforced Road," Second International Conference on Geotextiles, Vol II, pp 393-398, Las Vegas, NV.

Sowers, G. G., Collins, S. A. and Miller, D. G., Jr. 1982. "Mechanism of Geotextile-Aggregate Support in Low-Cost Roads," Second International Conference on Geotextiles, Vol II, PP 341-346, Las Vegas, NV.

Kinney, T. C., and Barenberg, E. J. 1982. "The Strengthening Effect of Geotextiles on Soil-Geotextile-Aggregate Systems," Second International Conference on Geotextiles, Vol II, pp 381-386, Las Vegas, NV.

Koerner, R. M., and Welsh, J. P. 1980. "Construction and Geotechnical Engineering Using Synthetic Fabrics," Supplementary Course Notes for American Society of Civil Engineering Continuing Education Course.

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Pease, G. D. 1989. "Rocks over Troubled Waters: A Floating Road for Tanks," Engineer, Vol 19, PB S-89-3/4, pp 22-25, Ft. Leonard Wood, MO.

Puffer, W. G. 1982. "Nonwoven Engineering Fabrics in Road Construction on Soft Soils," 10th Technical Symposium, Advances in Nonwoven Technology, pp 382-392, NY.

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Sowers, G. G., Collins, S. A. and Miller, D. G., Jr. 1982. "Mechanism of Geotextile-Aggregate Support in Low-Cost Roads," Second International Conference on Geotextiles, Vol II, PP 341-346, Las Vegas, NV.

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"Road Base and Construction Site Stabilization Using Aggregate and Geotextiles." 1984 (Jan). Better Roads, No. 1, Vol 54, pp 8-12.

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